CONTEMPORARY STATE OF MARKETABLE ECOSYSTEMS

Marine biota and ecosystem structures are normally described by variety of species, number of specimens, degree of species domination, interrelations of different types such as trophic, competitive, etc. (**Fig.**15). Let us first consider the state of the top elements of marine ecosystem. This includes sea mammals and sea birds, many of which are being protected on account of their scarce populations (**Fig.** 16).

Large-scale hydrological processes inertia

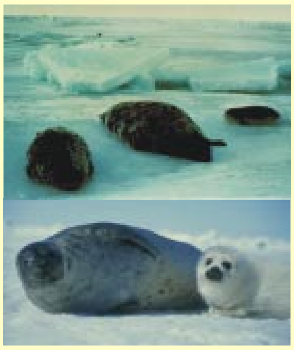
The position of ice-edge during a year

Relative stability of mammals natural habitats

Influences seasonal distribution of pagophil cetaceans and pinnipeds

The seasonal values of water temperature and characteristics of currents

Influence the seasonal cycle of biological productivity of seas and forage reserve of mammals, determine biodiversity: migrations of Atlantic mammals (wooly aphid) and appearance in the area of high latitude inhabitants (walrus, narwal)



Periods of freezing and intensity of ice fields and immobile ice destruction: the White Sea and Pechora Basin. The shift of drifting ice-edge, ice drift

Determine regions of pinnipedes packing (seal) and death rate during the brood period. The peculiarities of distribution of ice-bound mammals (bearded seal, harp seal, ringed seal, etc.)

The dynamics of hydrometeorological factors during the pinnipeds brood period during February-March (harp seal) April-May (ringed seal, bearded seal), June (common seal), November-December(atlantic seal)

Influence the formation of puprookeries and level of litter mortality. Ice-bound species: ice and snow thickness, ice cohesion, ice hummocks, fissures and polynias, stability of fastened ice. Open-water species: air temperature, stormy waves, snowfalls, winds, glacation of coastal areas and islands

Fig. 15. Impact of the climatic factors on the state of marine mammals populations

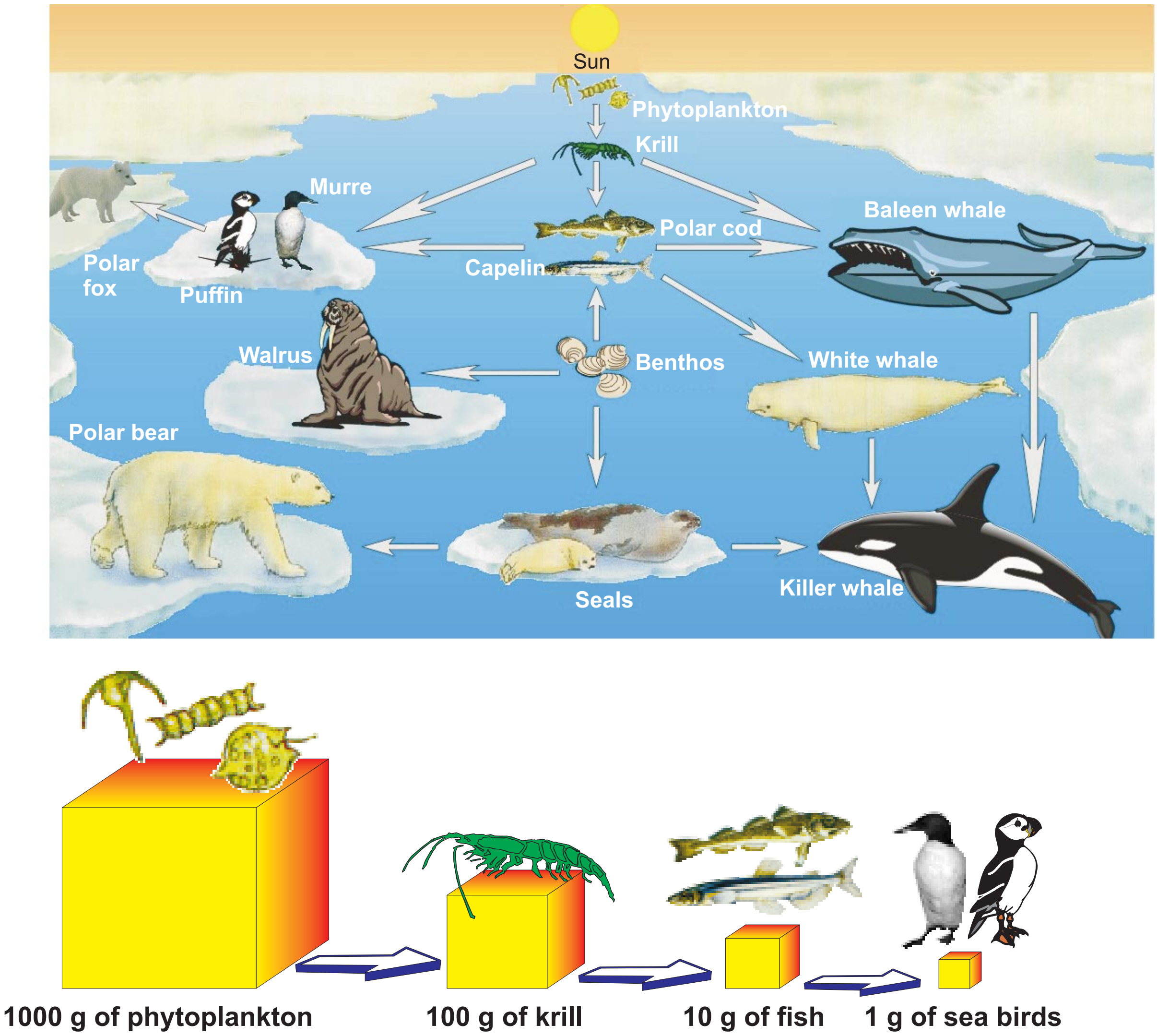


Fig. 16. Structure of the ecosystem of the polar seas. Universal pattern of food chains

MARINE MAMMALS

The history of whaling, which began in the 17th century, serves as a good example of the irreversible nature of biological changes when some species are put to the verge of extinction (**Fig.** 17). By the beginning of the 20th century, whale hunters nearly eliminated right whales and blue whales in the Arctic. Right whales stocks now stand at only 5,000–6,000 individuals. Many whales are registered in the Red Book.

In the middle of the 20th century, hunting shifted to the Antarctic. By the end of this century humpback whale stocks have been reduced to 3,000–5,000 individuals which constitutes only 3–5% of their original number. Finwhale population originally consisting of 500,000 individuals was reduced by 95 %. Only 200–1000 of blue whales survived, though their original stock had been 250,000 (Mallvitz 1998). Despite protection under the law since 1965 their population has not recovered. International Whale Protection Commission prohibited hunting of most of the whales since 1986. However, the Commission failed to stop hunting small whales (dolphins too).

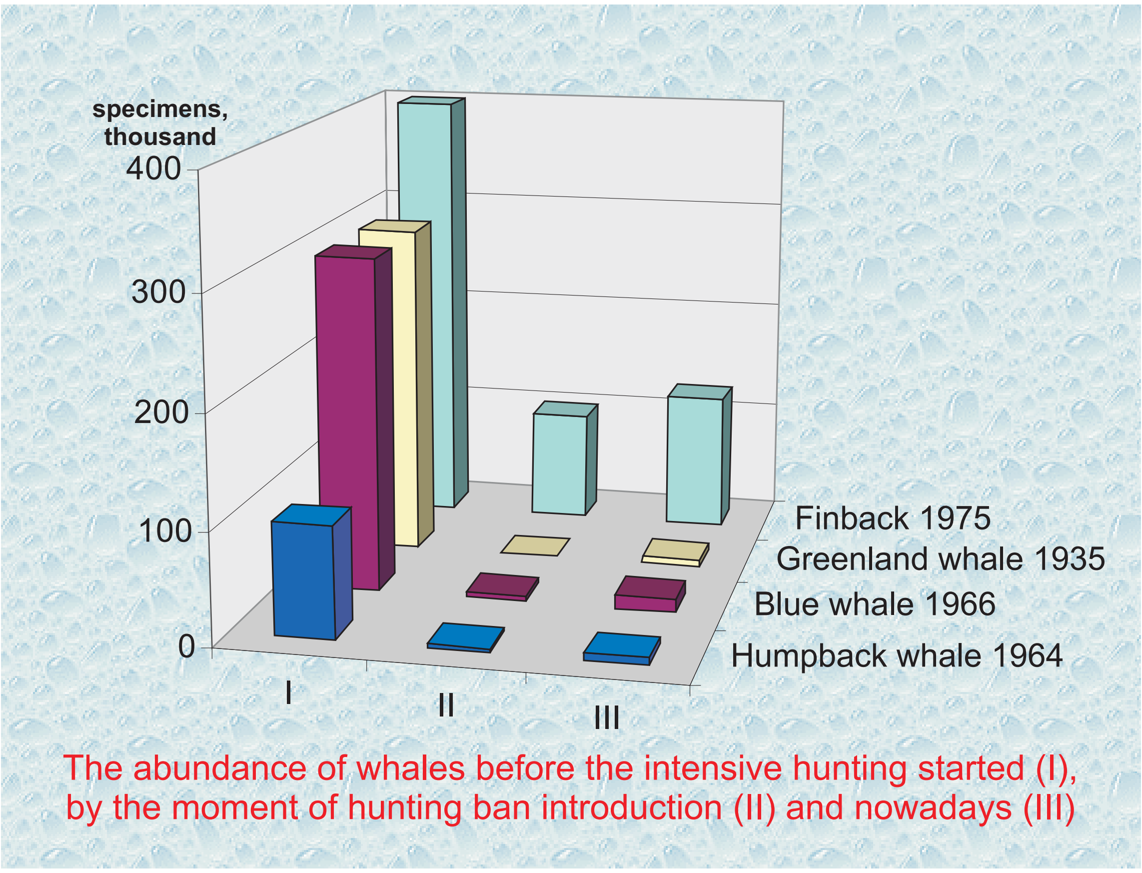
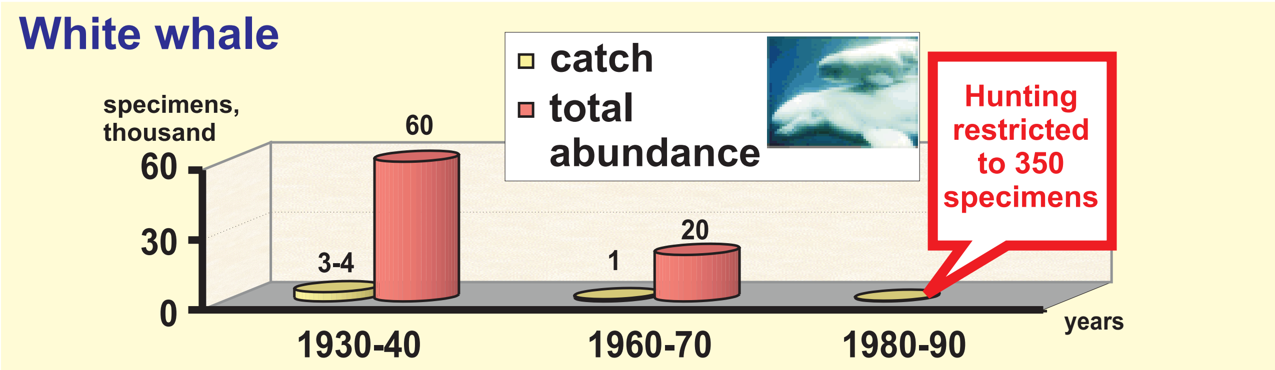
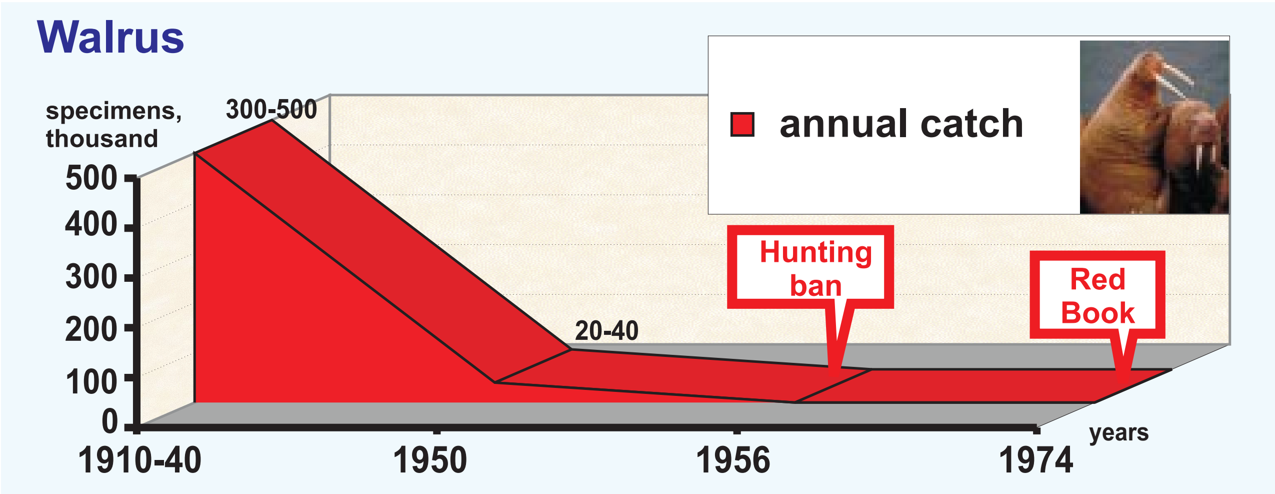


Fig. 17. Whaling





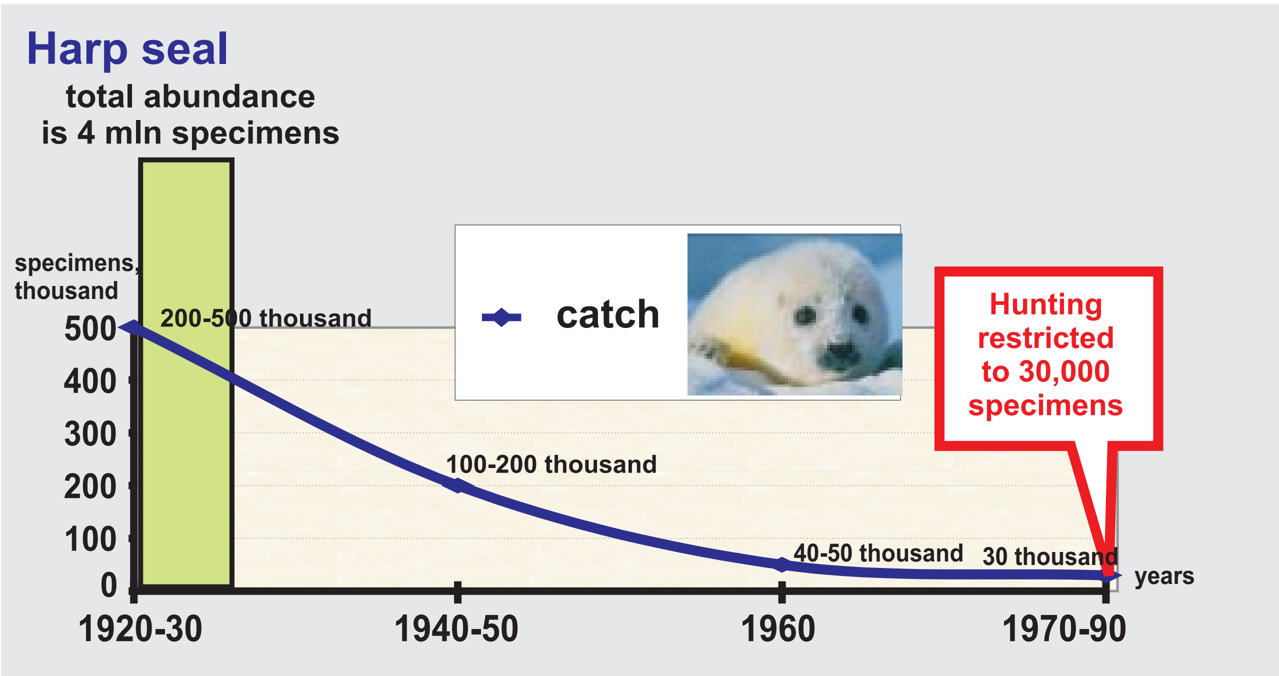


Fig. 18. Dynamics of marine mammals abundance

Lesser whales hunting developed the same way in the1930-60s. In 1938–1964, the Norwegians captured 78,000 smaller whales, mainly lesser rorqual (93%). In 1958, they captured in the Barents and adjacent seas the biggest amount ever, 5,000 individuals (**Fig.** 18). Intense regular hunting in the areas of stable concentration of animals resulted in a sharp decrease in their abundance and a consequent decline in whale hunting. White whale population has decreased by 3 times as compared to the levels of the 1930-40s (from 60,000 to 20,000 specimens). During that period the annual yield equaled to 3,000–4,000 specimens. Later hunting was restricted to 350 individuals until it was finally banned. In the Black-Azov seas basin cetaceans are represented by dolphins (**Fig.** 19). Their rather limited and urbanized environment is continually degrading. There were 1 mln dolphins in the Black Sea at the beginning of the 1950s. Despite a hunting ban since 1966, their population at the end of the 1980s hardly exceeded 50–100,000 specimens (Fashchuk 1998). Common porpoise had a commercial value in the 1920/40s and yields consisted of several thousands specimens (Geptner et al. 1976). Nowadays this species is extremely rare and therefore is not subject of study. There is little hope for recovery of its population on account of the ruined forage (sharp decrease in abundance of goby and other important food items). An even more prominent role in the European seas of Russia is played by *Platanistidae* family. They are competing with people for the same food resources and therefore reducing fish stocks. Norwegian experts have focused on artificial control over the populations of seals for fisheries' sake. Many of Canadian experts agree to kill 510,000 of harp seals and 30,000–40,000 of grey seals in order to preserve population of cod. However, such take might be rather hazardous for the population.

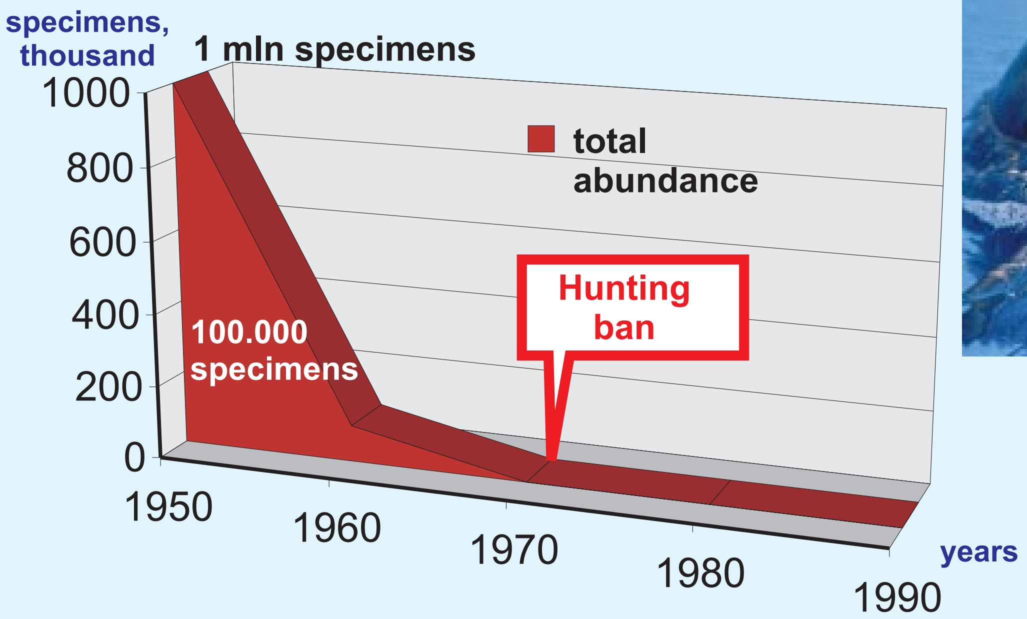


Fig. 19. Dynamics of dolphins abundance in the Azov Sea and the Black Sea basin during different periods of the 20th century

MMBI long term studies (Mishin and Stepakhno 1997) at the oceanarium showed that daily fish ration of seals is about 5 % of the animal weight. Seals also proved to prefer more nourishing fish such as herring, Atlantic mackerel and capelin to cod. The diet of the harp seal includes 53 species of fish and 54 species of invertebrates. These seals are basically omnivorous. Since the natural survival rate of cod juveniles may vary from 5 to 10 fold and seals graze upon predators of capelin and cod, it would not be unnatural to hypothesize that an increase in abundance of seals may even cause an increase in abundance of stocks of certain species of fish.

Statistics clearly show a progressive degradation of some *Platanistidae* populations because of hunting at the same time as fish stocks are declining. Acute shortage of fish in seals diets brought profound changes into the migration routes and was the cause of peculiarities of their life cycle (Kavtsevitch and Erokhina 1996). From the 19th up to the middle of the 20th century, Atlantic walrus hunting was absolutely unrestricted and its population declined from many hundred thousand to several dozen thousand specimens (Bytchkov 1976). In the 1950s, hunting of such Arctic residents as Polar bear and Atlantic walrus, inhabitants of drifting ice-fields and coast line of Novaya Zemlya, Franz Josef Land, Spitsbergen, was banned altogether. Walrus hunting was banned only in 1956, and in 1974 this walrus subspecies was registered in the Red Book.

By the end of the 20th century, gray and common seal alongside other representatives of Polar *Platanistidae* were registered as rare or protected species (Fig. 20). In the Southern seas the unfavorable environment and lack of protective measures have pushed the sea mammals to the verge of extinction. This also is the case for the monk seal in the Azov Sea.

The story of harp seal, which has been the most popular species of Platanistidae family in the Northern seas, is notable example. At first its population had been 4 mln specimens. During the 1920–30s seal hunters captured 200,000–500,000 specimens of all ages annually (Yakovenko 1967, Nazarenko 1984). Obvious degradation of the species in the1960s led to the imposition of a series of bans and restrictions on sealing. Nowadays only the whitecoats are the object of hunting. The hunting quota is about 30,000 specimens. A consequence of this harvesting pattern is an alteration of the stock age structure, i.e. the population is getting older as the number of young mature females is decreasing. Probably, harp seal whitecoats hunting should be banned as has happened in the case of the Caspian seal whitecoats.

Caspian seal (Phoca caspica) is endemic originating from the north and the only marine mammal of the Caspian Sea. The population of this seal became very soon distinct but preserved some biological characteristics such as bearing of pups on ice. In the 1930s yield was over 160 specimens (Ivanov 1992). After the World War II hunting was still on the high level (up to 100,000 individuals per year). In 1997, there was a serious decrease in yield (4,000 individuals) (**Fig.**21). Caspian seal pup hunting has been banned since 1998.

Reduction in abundance of representatives at the top level of the pelagic food web, sea mammals, inevitably undermines stability of the related ecosystems, and, in the end, results in their poor productivity (*Ecology of birds and seals in the seas of the North-West of Russia 1997*). It is well worth mentioning, that *Asclepiadasea* family and *Cetacean* family have low rates of natural reproduction. The reproductive cycle of such species as walrus and Greenland whale lasts for at least 3–4 years. The lifecycle of walrus unlike that of whales is affected by hydrometeorological factors. This is because representatives of *Asclepiadasea* family have to

FISHERY:
overcatch of the fishery reserves
HUNTING:
selective catch of pups
POACHING

Undermining of the forage basis, alteration of migration routes, food priorities, death of the animals in the hunting gears; reducing of the abundance, alteration of the age structure (ageing of the population), decrease of recruitment

CONTAMINATION:
(oil spill, domestic waste) impact of pollutants through the food chains

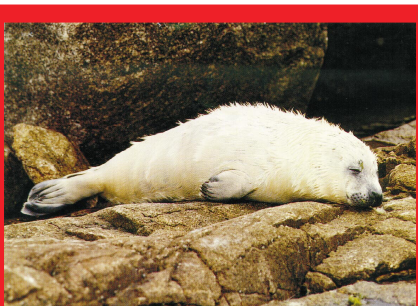
Death of the animals; destruction of the immune and reproductive systems, lowering of the reproductive functions, the irreversible degradation of the population

NAVIGATION OF THE ICE-BREAKERS' FLEET:
Winter-spring

Destruction of the ice fields in the areas of the pinnipeds pups layouts, death of the pups

ECONOMIC ACTIVITY:
Construction (including hydro-electric stations), fishery, procurement of sea-weeds and invertebrates

Leaving of traditional brood sites, death and injuring of the animals by catching gears and underwater communications



TECHNOGENIC NOISES:
Shipping, drilling platforms, geophysical experiments and training military

Increase of the number of the pups left by the females, diseases caused by stress, infrasound impact on communication and migrations of Baleen whale

Fig. 20. Anthropogenic stress on Arctic marine mammals

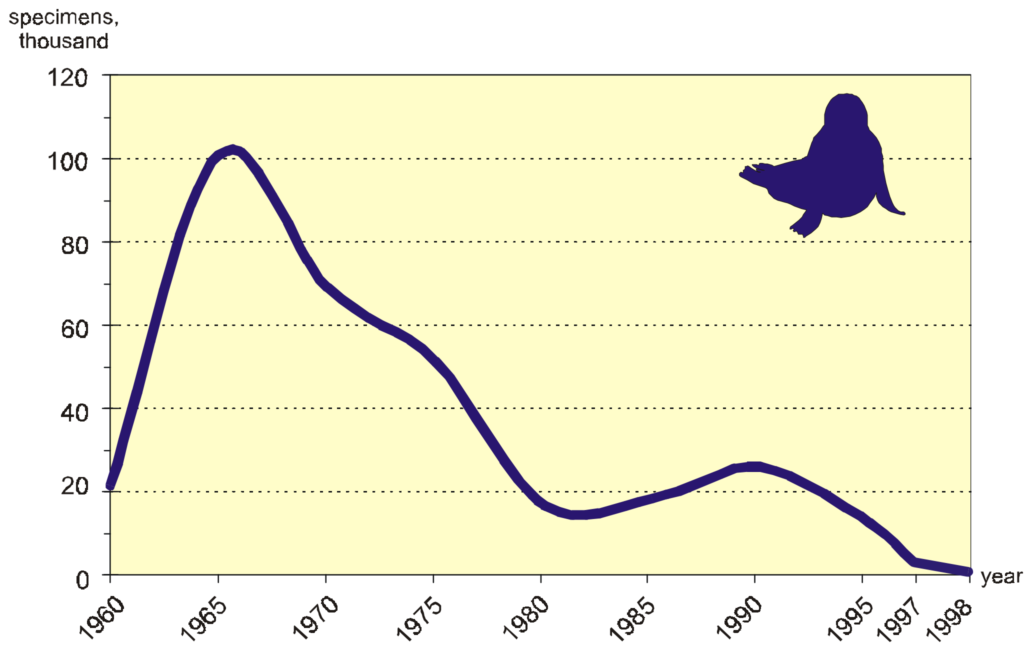


Fig. 21. Catch of seals in the Caspian Sea basin (by Ivanov et al. 1999)

leave water and go to the shore, ice or islands during the breeding season. That connection between the life cycle and climate is the reason, why the climatic pattern should be given serious consideration when modeling ecosystem dynamics.

MARKETABLE FISHES

Despite all efforts the unceasing decline in stock numbers and yields in the seas of the European part of Russia is the reality (**Fig.** 22).

The Black Sea. Average catch in the 1970–80s in the Black Sea amounted to 200,000 t. Approximately 90% of the catch consisted of sprats and anchovy (Dachno et al. 1997). The catch of such valuable marketable fishes as Black Sea scad, flounder, mackerel, mullet, ballan wrasse has declined an order of magnitude.

The catch pattern has changed considerably on the whole, for in the 1950s over 50% of the yield was comprised of valuable marketable species. 37% of them were such pelagic predators as bonito, Atlantic mackerel, Black Sea scad, bluefish. There were also considerable catches of Black Sea turbot, mullet and other members of Mullidae family. Only 36% of the catch consisted of short-lived pelagic species such as anchovy and sprat. Catch of migrants from the Marmara Sea, bluefish, bonito, Atlantic mackerel in the 1970s went down to only hundreds of tons. Large individuals of Black Sea scad are not evident catch any more and there are considerably decreased catches of Black Sea turbot, mullet and other members of the Mullidae family.

Introduction of Ctenophora into the reservoir resulted in an abrupt reduction of anchovy stocks, Clupeonella, Mullidae and some other marketable fishes (Gubanov and Serobaba 1997).

The Azov Sea. The Azov Sea environment is one of the world's most fertile fishing grounds with over 80 kg of fish per 1hectar. The peak catch was registered in the 1860s right before the beginning of continuous fisheries decline (Troitsky 1973). Yet catches of such valuable marketable species as sturgeon, zander, bream, sea-roach, zarthe, etc. still amounted to 150,000–300,000 t per year in the 1930–50s (**Fig.** 23–25).

Nowadays the species diversity of these marine living resources have declined dramatically (Makarov and Semenov 1996). For example, the yield of traditional for the Azov Sea sea-roach in the 1930s was 20,000–25,000 t and common carp 74,000 t per year and from 1990–1996 catches of sea-roach declined to 100–250 t per year and catches of zander were only 1,000–3,000 t. The situation with sazan stock is nearly the same, though in this case the short fall is partly compensated by rearing of common carp at aquafarms (**Fig.** 23).

The fate of sturgeon family causes concern. During the 1960s sturgeon catch in the Azov Sea reached 10,000–14,000 t (Troitsky 1973). However, by 1937 in the Azov Sea and in the mouth of the Don River the catch comprised 7,000 t and by 1997 it was down to 450 t. The 10 –20 fold decline in catches of sturgeon family, also typical of the other fishes, is far too obvious.

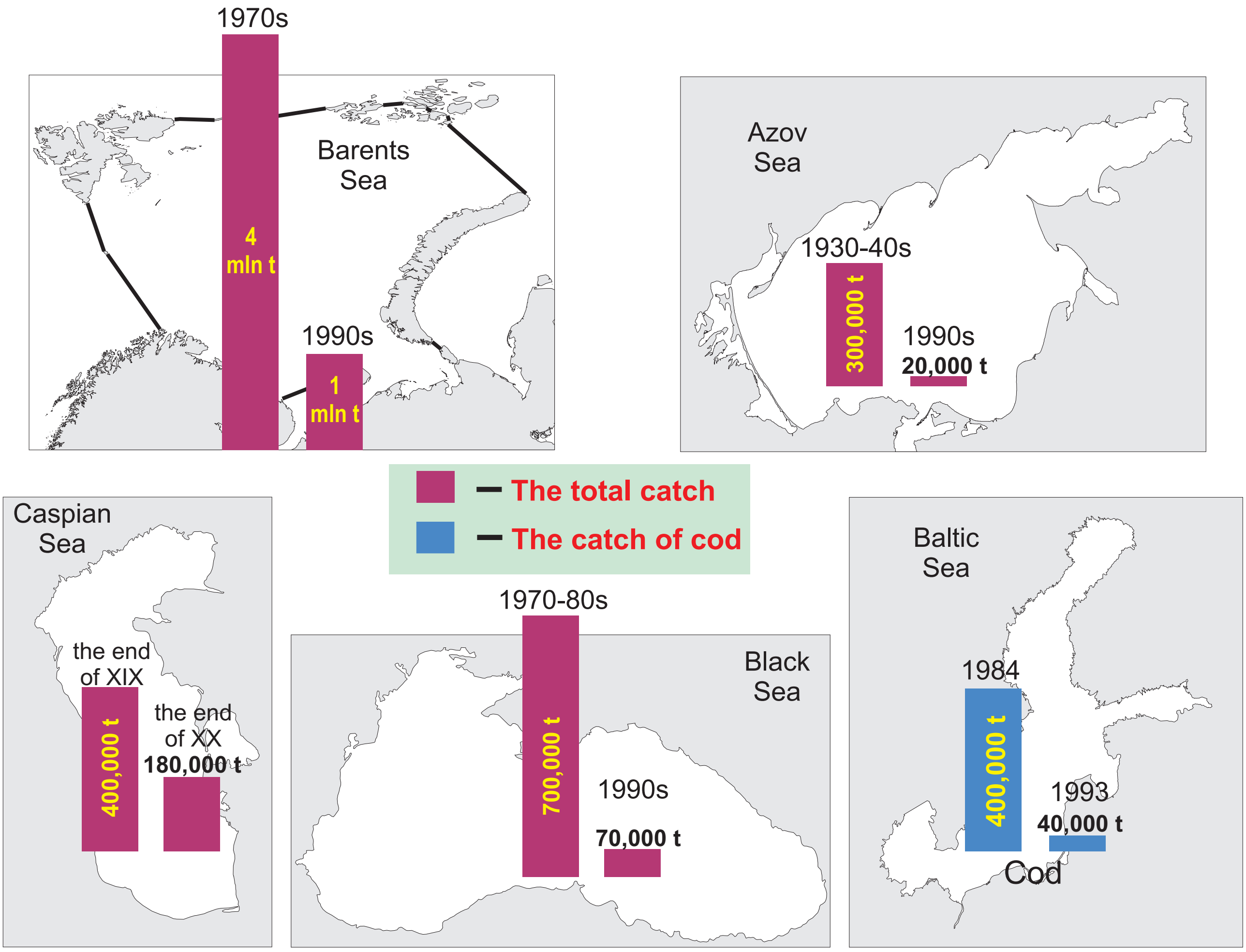


Fig. 22. Total catches of fish in the seas of the European part of Russia in the past and at present

The catches of the main marketable fish in the Azov basin, tons

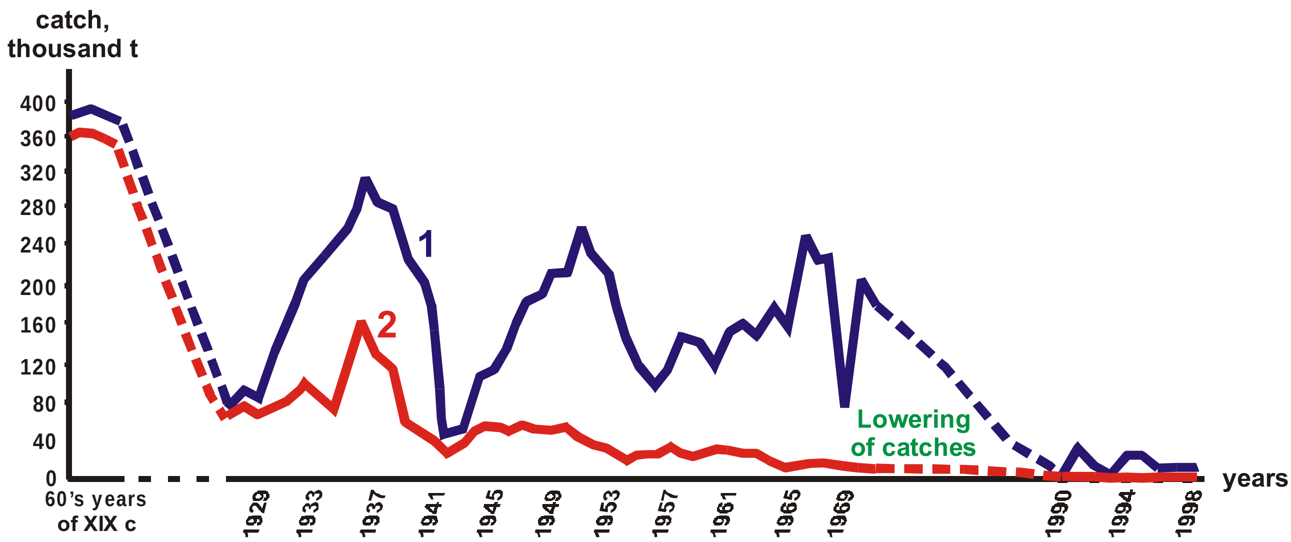
The species of fish	Maximum catches		1990	1991	1992	1993	1994	1995	1996
	tons	year							
Sturgeon family*	7300	1937	1012	1021	1006	1202	1224	790	594
Also									
sturgeon			677	759	756	893	874	476	412
starred sturgeon			334	262	246	307	348	312	181
white sturgeon			1	-	4	2	2	2	1
zander	73700	1936	1446	1266	975	699	1092	1367	3135
bream	46500	1936	1715	1663	1564	1387	1025	887	960
sea-roach	18200	1936	182	101	129	140	476	244	244
goby	91700	1957	208	432	106	249	305	130	23
anchovy	142600	1974	43	46	9517	3123	17950	15049	4659
kilka	125800	1982	1370	27055	3018	281	4500	6969	1445
pleuronectidae family	1800	1986	530	403	365	273	263	126	144
haarder	1600	1996	-	-	52	74	365	981	1600
All	523600	1936	6499	31989	16732	7428	27200	26543	12419

* Maximum catches of sturgeon were in 1937, but list of species is missing. The next to maximum catches with list of species was in 1935, when the total catch was 4700 tonns,including:
- sturgeon - 900 t
- starred sturgeon - 2900 t
- white sturgeon - 900 t

The catches of fish by enterprises of the Russian Federation, thousand tons

Year	Salmon	Sturgeon	Herring	Sprat	Big fish								Roach	Small fish	Other	All
					zander	bream	sazan	catfish	asp	pike	other	all				
1990	0.01	11.7	2.0	137.0		13.6	3.7	8.8	-	3.5	0.1	30.7	18.7	9.0	0.02	209.1
1991	0.01	8.5	1.3	124.0	1.9	12.4	4.43	7.9	0.2	3.1	0.1	30.0	17.5	10.0	0.1	191.4
1992	0.03	7.5	1.9	100.5	3.7	15.2	3.4	5.5	0.1	3.7	0.1	31.7	19.5	9.8	0.02	170.9
1993	0.03	4.3	1.4	73.4	2.1	15.9	1.8	3.9	0.2	3.4	0.1	27.4	18.6	6.8	0.1	132.0
1994	0.05	3.2	1.3	77.2	0.8	17.9	1.8	3.8	0.2	2.6	0.1	27.2	15.8	6.8	0.03	131.5
1995	0.05	2.3	1.5	80.0	0.84	18.8	2.2	4.4	0.3	3.2	0.06	29.6	13.7	9.1	0.01	136.2
1996	0.03	1.3	1.9	74.4	0.7	18.2	3.6	5.8	0.1	3.5	-	31.9	14.9	9.5	-	133.9

Fig. 23. Catches of the main commercial fish species in the Caspian Sea and in the Azov Sea (by Volovik et al. 1998, Mazhnik and Scharzkopf 1998)



1 - total catch
2 - catch of the valuable fish

Fig. 24. Dynamics of the main commercial fish species catch in the Azov Sea basin

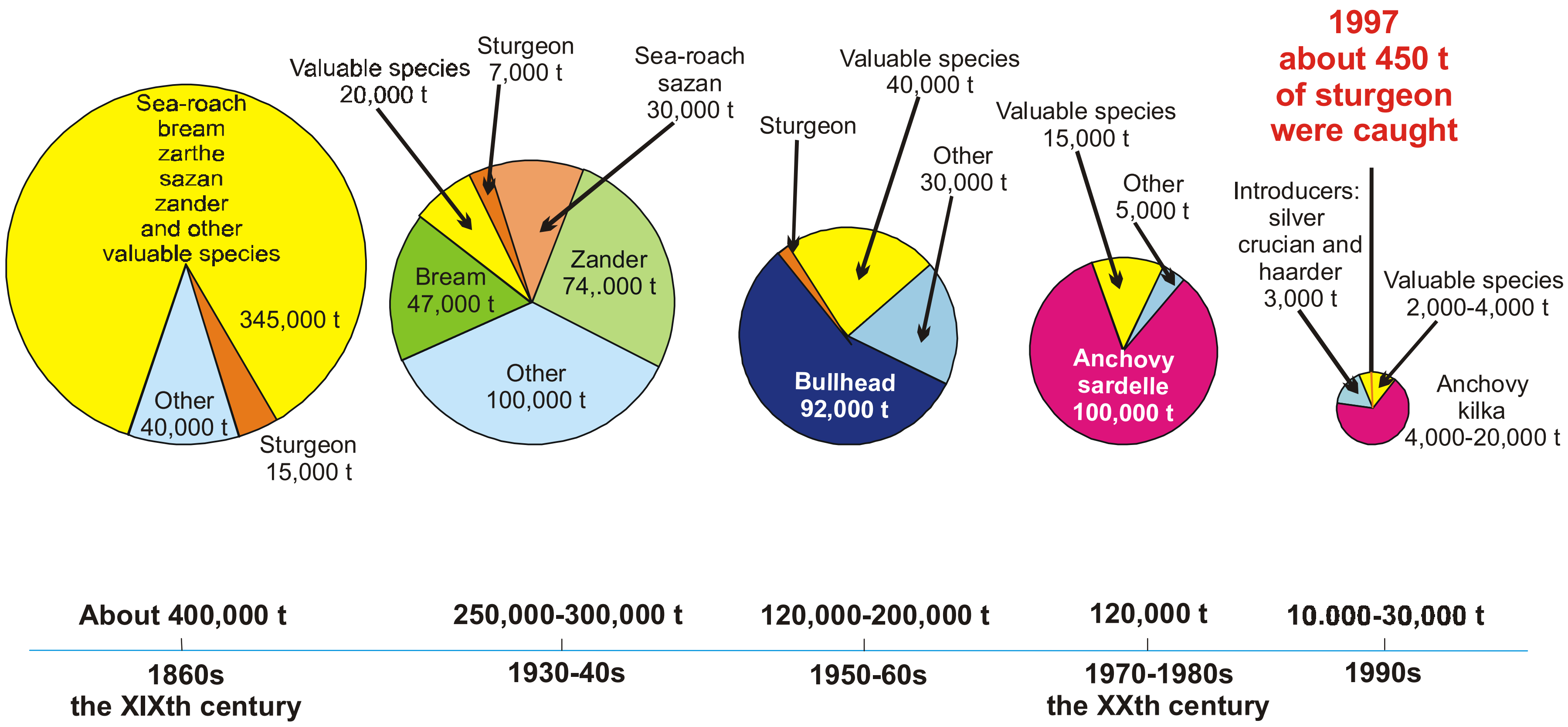


Fig. 25. Dynamics of the main commercial fish species catch in the Azov Sea

Experts of *All-Russian scientific-research institute of fishery and oceanography (VNIRO)* and *Azov Fishery scientific-research institute* found out that sturgeon family reproduction now almost completely depends upon efficiency of aquafarms. While rearing has made it possible to maintain reproduction of the Russian sturgeon, albeit at a low level, stocks of Caspian sturgeon, the great sturgeon are on the verge of extinction (Volovik et al. 1996). Moreover, the maintenance of the genetic diversity in order to preserve the species might arise in the near future.

The Caspian Sea. In many respects a similar sturgeon situation is observed in the northern part of the Caspian Sea and in the Volga River estuary (**Fig.** 26, 27) where over 90% of historical catch of sturgeon family were made. And by 1995 the world catch of sturgeon was only 6,610 t (by *FAO*) with the catch in the Caspian basin 4,400 t (70%) including Russian 2,300 t. At the end of the 19th century yield in this area was 40,000 t.

Sturgeon family stock dynamics causes great concern because their stock has declined 2 times since 1991 (Vlasenko 1997). There is a distinct trend of decrease in parental stock migrating to the rivers of the Caspian basin during the reproductive period is observed as well as a general decrease of the stock in the sea. Migrations of sturgeon to the spawning areas decreased from 371,000 specimens in 1991 to 70,400 specimens in 1996; migrating stock of Caspian sturgeon decreased from 234,000 to 89,800 specimens (Chodorevsky et al. 1997).

Major sources of recruitment for the sturgeon family are natural reproduction and rearing of juveniles (**Fig.** 28). Because of artificial rearing stock abundance decline in the Caspian Sea was slowed down. Still the yield of sturgeon family in Russia went down to 1,300 t in 1996 (Magnik and Sharcscopf 1998). Most of the natural reproduction of sturgeon family in the basin of the Caspian Sea belongs to Russia. The reason is that 69% of natural reproduction take place in the rivers of Russia.

Year	Sal-mon	Stur-geon	Herring	Sprat	Big fish									Grey mullet	Roach	Small fish	Other	All
					zander	bream	sazan	catfish	asp	pike	Black Sea roach	Other	all					
1900	1.1	29.8	73.6		29.1	14.9	23.8	4.3	4.0		0.5	0.01	76.6		119.7			**300.0**
1905	0.3	27.2	102.0		21.8	24.5	11.1	8.0	1.5		0.6	-	67.5		184.7			**381.7**
1910	0.6	23.1	168.5		48.2	8.5	13.9	5.7	1.7		1.2	-	79.2		175.6			**447.0**
1913	0.8	28.5	238.2		42.3	10.6	28.1	11.2	3.3		0.7	0.01	96.2		136.6			**590.3**
1915	0.7	26.9	286.9		14.1	9.6	38.4	11.0	1.5				74.6		157.3			**546.4**
1917	0.2	8.5	319.7		31.6	11.5	63.8	5.8	1.9		-	-	114.6		162.8			**605.8**
1920	0.1	2.9	48.9		8.1	1.9	6.2	0.7	0.7			-	17.6		50.8			**120.3**
1925	0.4	12.1	165.1		45.6	18.6	17.3	2.4	2.8		-	-	86.7		174.5			**438.8**
1930	0.4	13.7	134.1		90.2	25.6	12.9	2.6	3.5		1.3	-	146.1		263.4			**557.7**
1935	1.1	19.3	57.6	4.5	58.6	105.0	16.4	4.9	3.3	1.9	1.4	0.6	192.1		170.1	27.2	2.1	**474.0**
1940	1.1	7.5	136.5	8.9	35.4	62.0	14.8	2.9	1.6	5.0	2.1		123.8	0.1	51.4	17.9	2.3	**349.5**
1945	0.3	3.6	103.5	9.2	32.1	87.7	18.3	1.6		4.3	0.4	0.6	145	0.1	66.5	12.0	1.1	**341.3**
1950	0.4	13.5	56.1	21.7	31.4	75.4	33.8	10.1	2.5	4.0	0.3	1.6	159.1	0.3	59.6	19.9	1.0	**331.6**
1955	0.1	10.5	45.9	133.8	30.0	37.1	21.7	10.0	3.2	11.3	1.2	0.3	114.8	1.6	109.0	38.9	1.4	**456.0**
1960	0.01	10.1	54.9	176.0	14.6	23.3	7.6	5.9	2.3	5.9	0.5	0.1	60.2	0.7	64.1	20.3	0.3	**386.6**
1965		14.9	3.5	343.2	6.8	18.9	4.0	10.0	0.4	5.3	0.1	-	45.5	0.6	18.4	23.8	0.2	**450.1**
1970	0.01	16.1	1.9	423.2	4.0	22.5	5.1	14.5	0.7	7.0	0.02	0.03	53.8	0.6	12.7	22.3	0.2	**530.8**
1975	0.01	23.3	1.6	342.5	4.6	17.7	7.0	15.3	1.0	5.5	0.04	0.02	51.1	0.5	26.2	17.9	0.1	**463.2**
1980	0.02	25.1	1.1	304.8	1.0	4.0	3.8	9.2	0.2	4.7	0.1	0.01	23	0.2	5.8	23.2	0.1	**383.3**
1985	0.03	21.2	3.5	269.4	1.6	8.5	6.7	8.4	0.3	3.6	0.1	0.1	29.3	0.2	8.6	11.7		**343.9**
1990	0.01	13.7	2.3	235.3	4.6	16.9	4.2	10.4	0.3	4.2	0.05	0.1	40.7	0.2	20.8	11.0	0.0	**324.0**
1995	0.05	2.9	1.6	107.9	4.1	25.3	2.6	5.4	0.7	3.7	-	0.1	41.9	0.02	16.2	10.6	0.1	**181.2**
1997	0.02	1.8.	2.3	102.0	4.1	27.5	3.2	8.0	0.7	3.5	-	0.4	47.4	0.02	12.1	12.7	-	**178.3**

Fig. 26. Catch of fish in the Caspian Sea basin, thousand t (by Ivanov V .P. et al. 1999)

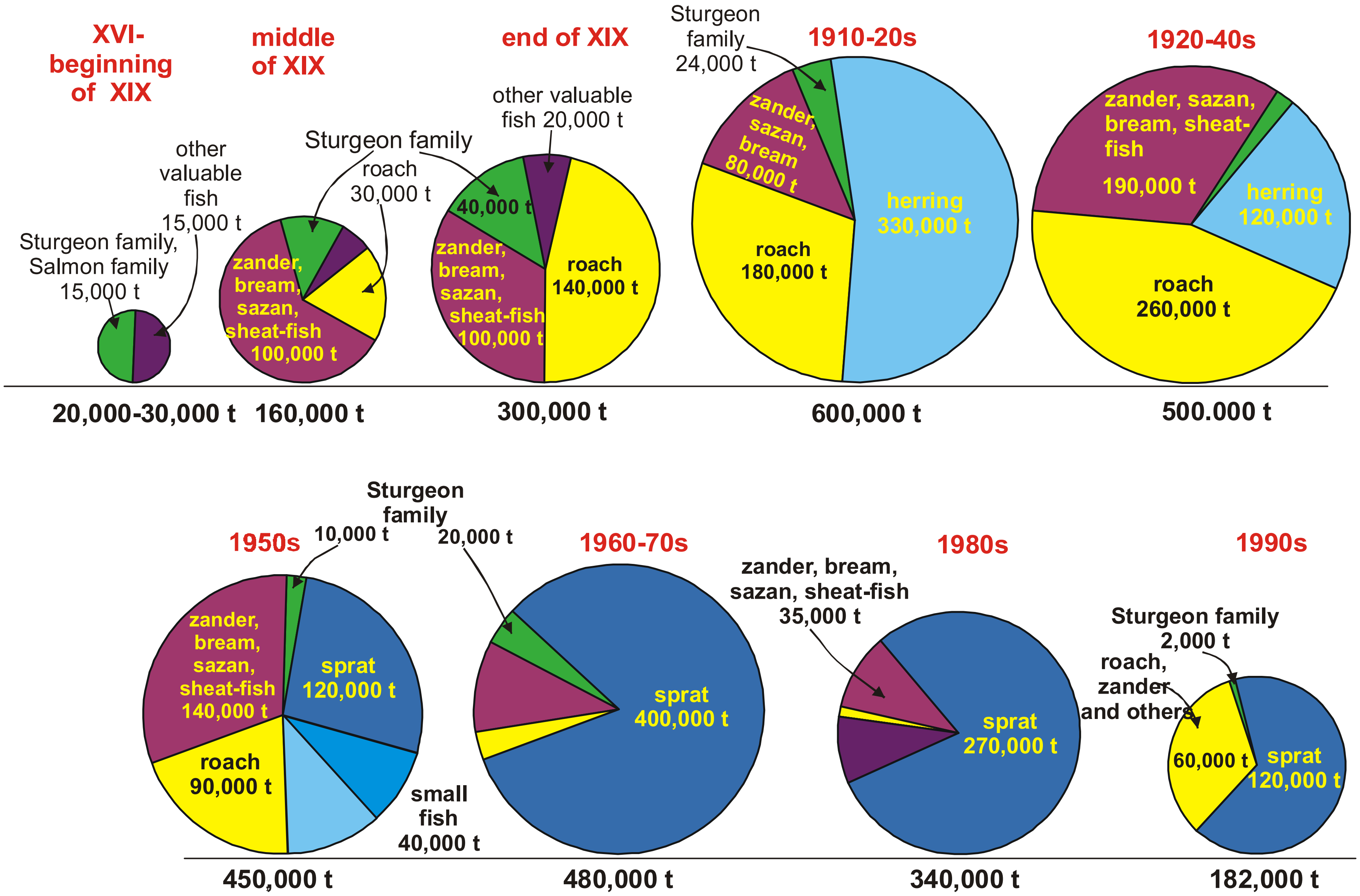


Fig. 27. Dynamics of different fish species catch in the Caspian Sea basin (by Ivanov V. P. et al. 1999.)

The basin of the Caspian Sea is characterized by the diversity of river and semianadromous fishes. In 1900–1910 catches of larger fishes (zander, bream, etc.) exceeded 100,000 t and yield of Caspian roach amounted to 200,000 t. In 1926 yields of larger fish and Caspian roach comprised 110,000 t and 226,000 t. Larger fishes and Caspian roach yields went down in the 1970–80s because the conditions were unfavorable for reproduction. The most significant decline in the Northern Caspian productivity occurred in the 1960s as the result of the Volga river runoff regulation and in the 1930s and 70s because of the sharp lowering of the sea level (Vlasenko 1997). In the 1990s yield of river fishes and Caspian roach never exceeded 30,000 and 25,000 t respectively, i.e. a 4–10 fold reduction in the yields as compared to the yields in the early years of the century.

The Baltic Sea. Cod stocks continuously decreased from 391,000 to 40,000 t over the period 1984–1993. For several years Russia has been calling for a moratorium on fishing cod since the development of fishery threatens the very existence of the stock. Kilka catches at the beginning of the 90s range from 20,000 to 50,000 t. Total catches in the Caspian Sea are 4–5 times less than they used to be (Karaseva 1997).

The White Sea. The output of the White Sea is comparatively small. Its benthos is extremely poor. The total catch in the sea ranges from 30,000–40,000 t in the 19th century, 5,000–15,000 t in 1940–60s. In the 1990s catch comprised 2,000–4,000 t.

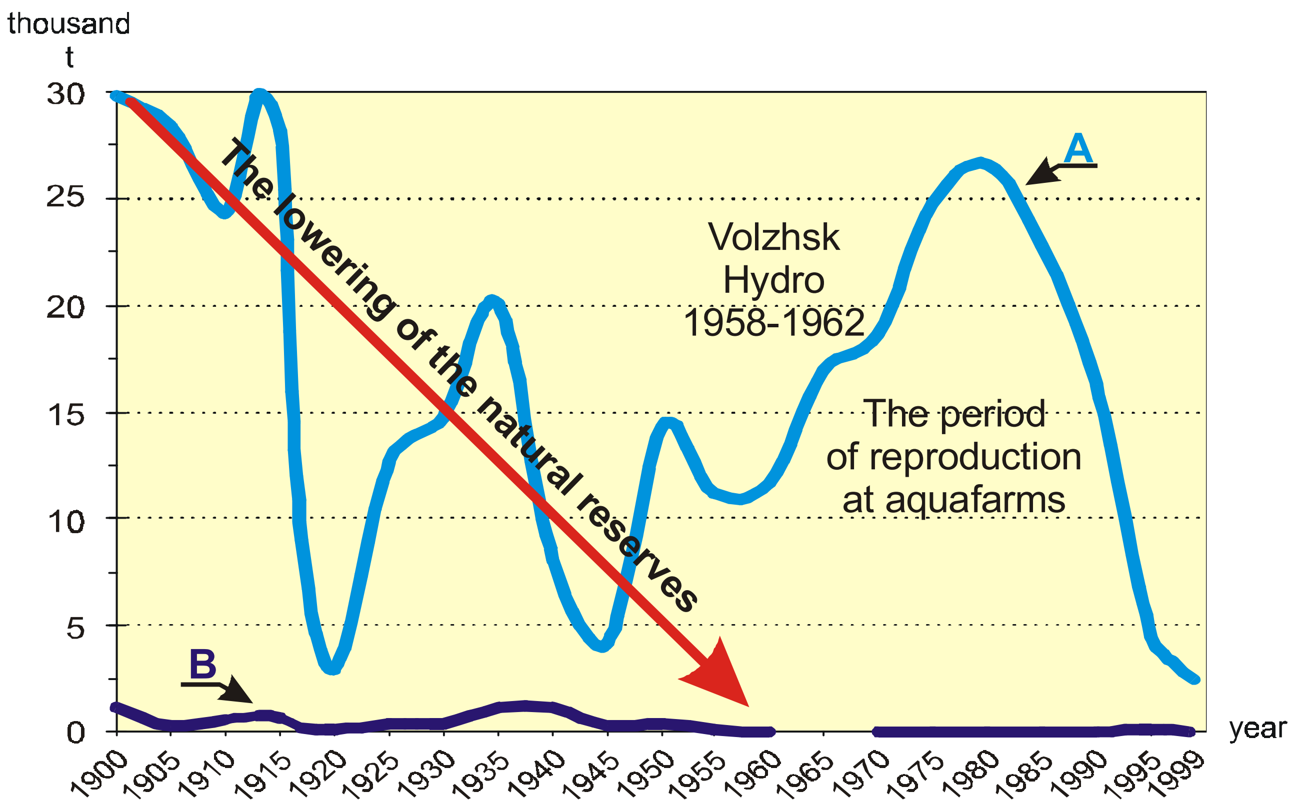


Fig. 28. Catches of sturgeon family (A) and salmon family (B) in the Caspian Sea basin (by materials of Ivanov V. P. et al. 1999)

A regular fishery in the White Sea has been carried out since the 12th century. The commercial stocks include salmon, navaga, humpback salmon, white fishes, herring, cod and arctic flounder. The most important marketable species are salmon, Arctic salmon, herring and navaga. Peak catches of Arctic salmon never exceeded 200,000–400,000 t. Catches of all other species are not significant and their catches are not limited. Polar cod migrates to the White Sea during the periods of cooling.

Herring. Before the middle of the 19th century catch comprised 32,000 t, during the 1860–70s catches were about 10,000 t. In 1928 the catches declined to 8,200 t per year, and in 1998 the catch was only 650 t.

Cod. Normally it does not exceed 8% of total catch. Over the period of 1936–51, catches ranged from 0.93 t (1948) to 142.7 (1940). Catches of cod in Kandalaksha Bay varied between 0.9 to 143 t over the period 1951–1963. According to the Fishery Committee of Karelia, the catches in 1951–1987 ranged from 0 (1963, 1980, 1982) to 315 t (1957).

Navaga. The lowest catches of navaga (580–670 t) were registered at the end of the 1930s. Commercial stock biomass in the 1980s was 5,000–5,500 t. Nowadays maximum catch is 1,000 t (**Fig.** 29).

The Barents Sea is one of the world's richest seas. In the late 1970s, yield of sea products in the Barents Sea amounted to 4.5 mln t annually. Only cod catches were at the level of 1.2–1.4 mln t (**Fig.** 30, 31). By the end of the 1980s fishing of herring, capelin and polar cod was stopped. At this time the total catch was 300,000 t. By the beginning of the 1990s, the cod yield went down to 210,000 t and parental stock biomass was at its lowest since introduction of fishery into the area (*Atlantic cod: biology, ecology, fishery 1996. Edited by G.G. Matishov, Rodin*).

Period	Navaga	Herring	Salmon	Other marketable fish	Total catch
1956-1960	1232	2190	499	1040	4961
1961-1965	1280	2192	331	506	4309
1966-1970	1360	583	285	718	2946
1971-1975	1645	750	394	826	3615
1976-1980	1199	1285	342	357	3183
1971	1317	742	239	237	3535
1982	1448	1005	230	407	3090
1983	2479	1032	322	637	4470
1984	2190	1046	329	246	3811
1985	2257	1453	382	210	4302
1986	1566	1858	332	214	3970
1987	2138	1900	344	190	4572

Fig. 29. Annual average catch of fish in the White Sea (t)

By the beginning of 1995, when brood and commercial stocks of cod were 1.9 and 0.8 mln t respectively, it was possible to recommend sustainable harvest of 740,000 t. Nevertheless, optimistic forecasts have failed to materialize and quotas have been constantly reduced over the last three years (1999–520,000 t of cod).

Let us describe dynamics of decrease in catches of other marketable species without going into further detail. Yield of Atlantic cod reached its peak of 2 mln t in the 1960s. The stock became of no commercial interest in the 1970–80s when catches comprised nearly 10 fold less historical values (**Fig.** 32). It is only in the mid 90s when the commercial stock was restored. Total catch of herring in 1997 comprised 1.3 mln t, but it is hard to say how resistant to the growing fishery stress it will be. Yields are influenced by annual stock abundance fluctuations which are characteristic of most stocks in the Barents Sea. And even here we find a long term tendency to decrease. E.g. Ocean perch catch 270,000 t in 1976 and 14,000 t in 1995, black halibut catch 76,000 t in 1971 and 12,000 t nowadays (Shleinyk 1996).

Still the most drastic changes happened to capelin. General stock size of 4 to 7 mln t and brood stock of 1 to 4 mln t were providing good yields in the 1970s. The peak catch of capelin comprising 3 mln t was recorded in 1977 (**Fig.** 33). At the beginning of the 1980s, the average catch was approximately 2 mln t. This resulted in reduction of general and brood stocks. In 1986, commercial fishing of capelin was banned. Capelin and northern shrimp are not only important fishery objects, but also constitute the main part of cod diet (and of other benthic fish), seabirds and sea mammals. That is why their abundance is essential for the Barents Sea ecosystem.

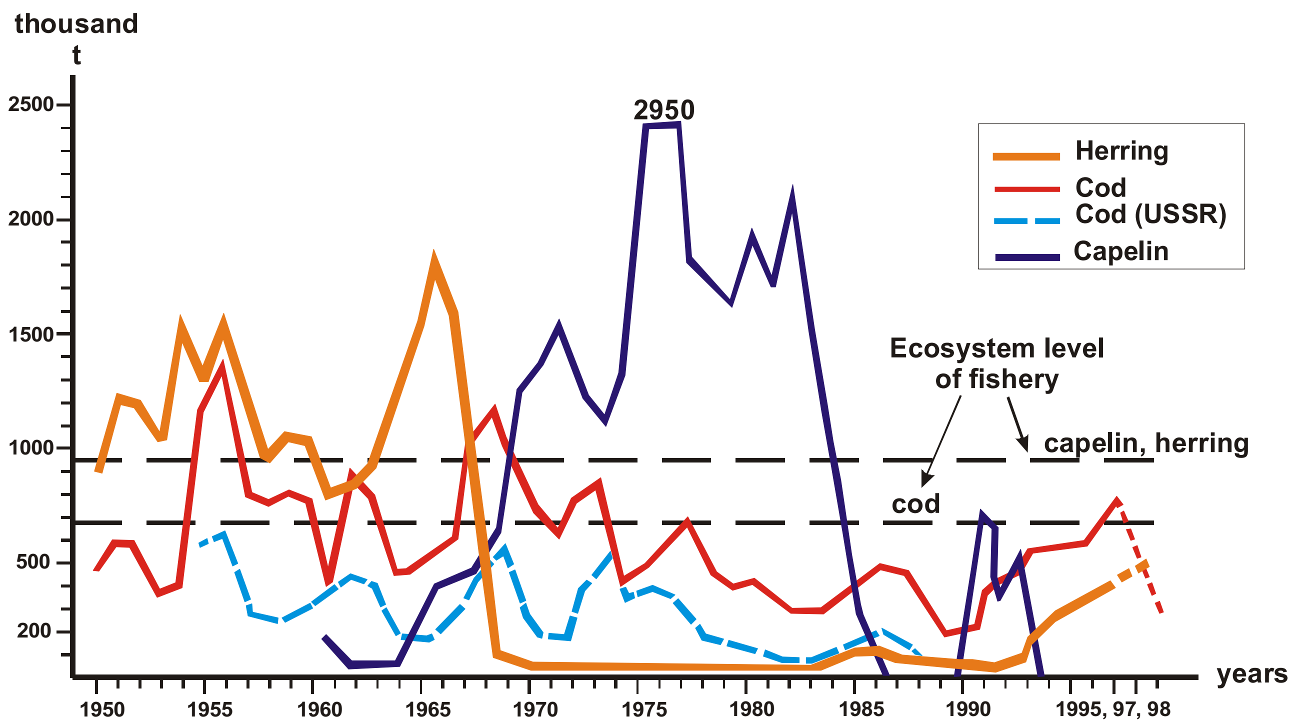


Fig. 30. Fluctuations of the world catch of some commercial fish species (the Barents and the Norwegian seas) by ICES data

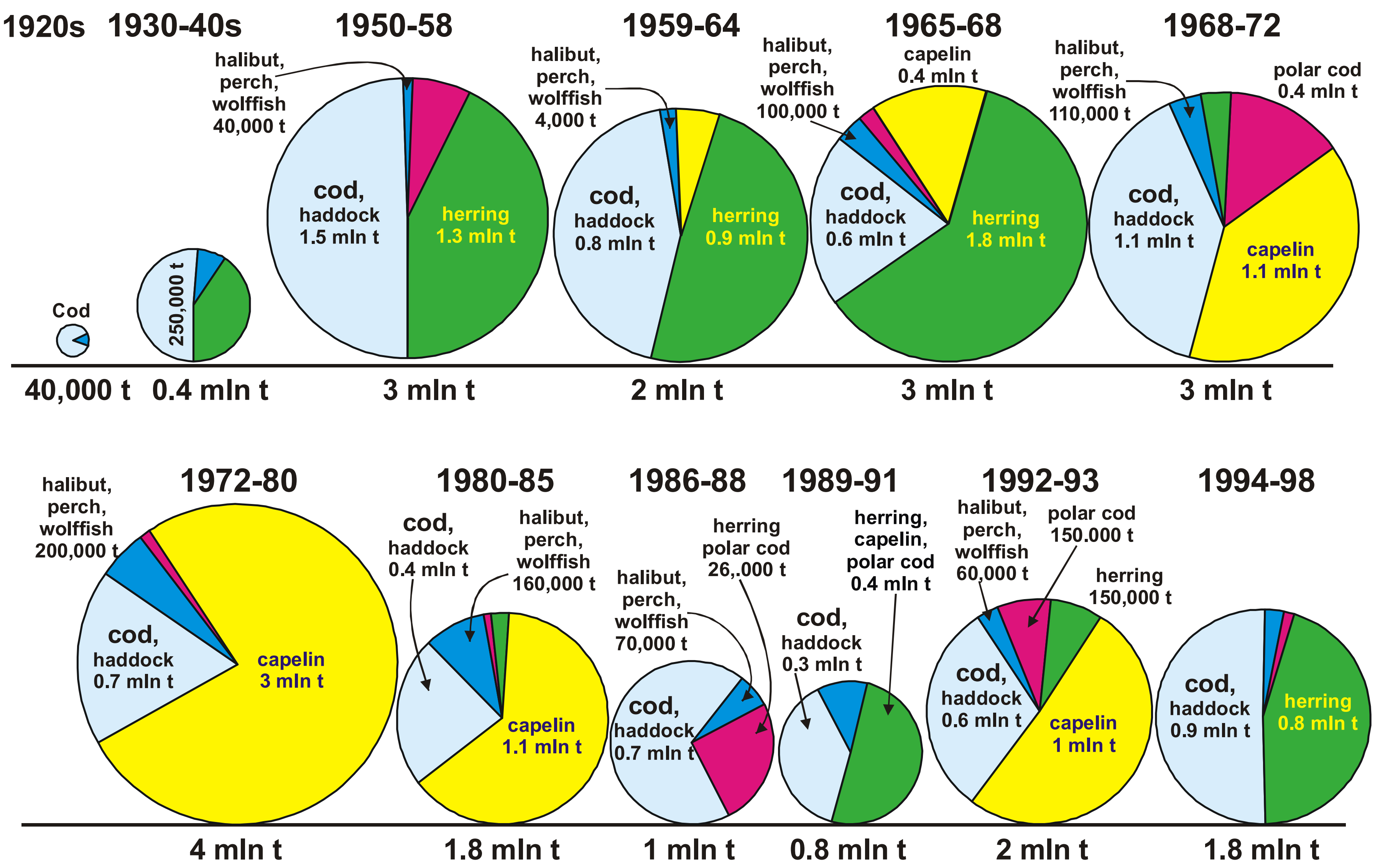


Fig. 31. Dynamics of catch of different fish species in the Barents Sea (by PINRO *and* ICES *and other materials)*

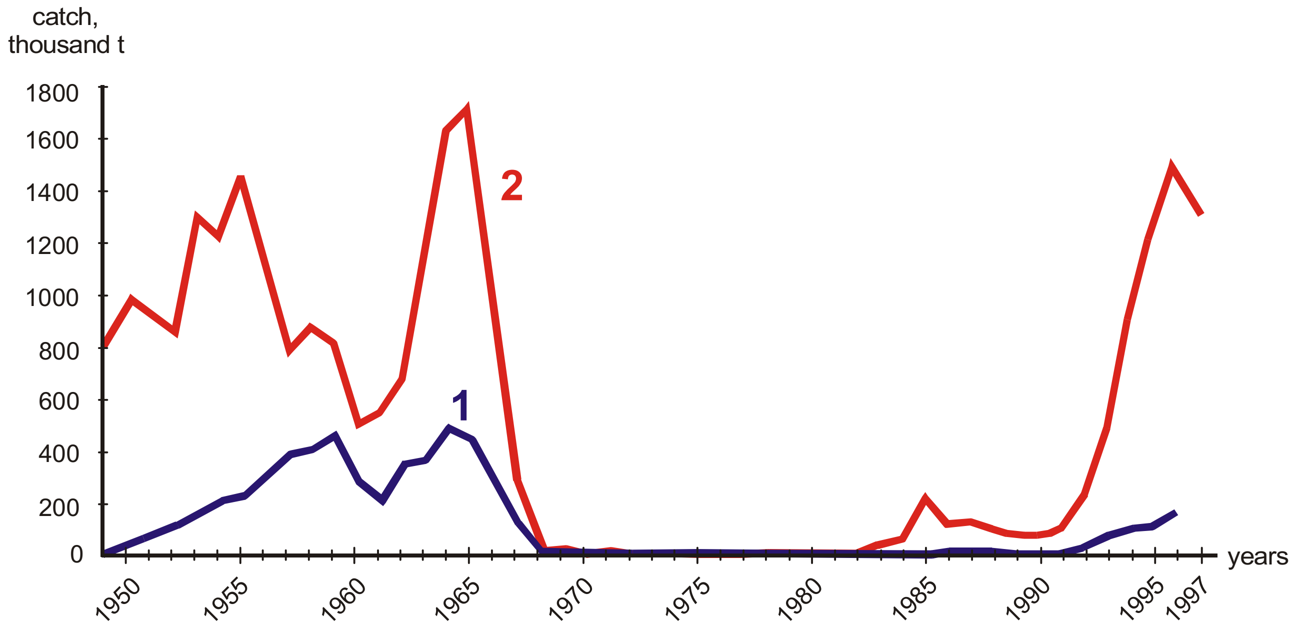


Fig. 32. Catch of herring by Russian fisheries (1) and by fisheries around the world (2)
(by PINRO data, 1998)

Year	Total catch							
	Spring				Autumn			All
	Russia	Norway	Other	All	Russia	Norway	All	
1976	228	1252	—	1480	368	739	1107	2587
1977	317	1441	2	1760	504	722	1227	2987
1978	429	784	25	1237	318	360	678	1915
1979	342	539	5	886	326	570	896	1783
1980	253	539	9	801	388	459	847	1648
1981	429	784	28	1240	292	454	746	1986
1982	260	568	5	833	336	591	927	1760
1983	373	751	36	1161	439	758	1197	2358
1984	257	330	42	629	368	481	849	1478
1985	234	340	17	590	164	113	278	868
1986	51	72	—	123	0	0	0	123
1987	Fishing banned							
1988	—"—							
1989	—"—							
1990	—"—							
1991	159	528	20	707	195	31	226	933
1992	247	620	24	891	159	73	232	1123
1993	170	402	14	586	0	0	0	586
1994								
1995	Fishing banned							
1996	—"—							
1997	—"—							

* Mainly the Faeroes Islands

*Fig. 33. Total catch of the Barents Sea capelin by the Russian, Norwegian and other fisheries in spring and autumn 1976-1997, thousand t (*by ICES data*)*

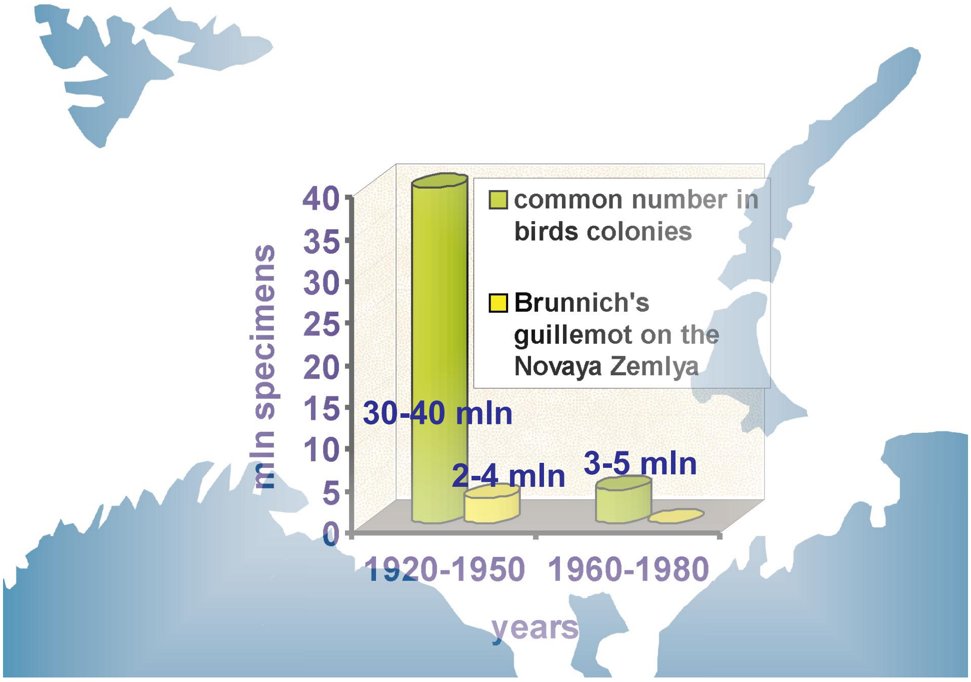


Fig. 34. Dynamics of birds abundance in the Barents Sea in the 20th century (by published data)

In terms of commercial value, Atlantic salmon is top of the list in the North, enjoying the same status as the sturgeon family in the Southern seas. Over 2,000 t of salmon were captured last century in the basins of the Barents and the White seas annually, i.e. 10 times as much as at the end of the 20th century (Alekseev and Ponomarenko 1997). Now, the arctic salmon stock together with Pechora salmon stock is on the verge of extinction and urgent steps should be taken to restore them.

Commercially valuable species of benthic invertebrates (Polar shrimp, Iceland scallop) were under heavy fishery stress. Catch of scallop alone in 1990–1997 in the South-East of the Barents Sea grew from 2,000 to 14,000 t per year. Nowadays stock of this mollusk is decreasing and restoration of its abundance might take 10–15 years.

Intensive extraction of Polar shrimp in the Barents Sea was started at the beginning of the1980s. In 1984–1985, annual average catch comprised over 120,000 t. Later catches were getting poorer until they hit the bottom with less than 24,000 t in 1995.

Large scale use of trawling equipment meant for benthic fishes had a most destructive effect upon benthos. These trawls are primarily used for fishing Arctic cod and Azov goby. Catches of goby in the 60s reached 92,000 t annually (Spivak et al. 1995). It is easy to imagine how deep the «disturbance» of the benthic community was in the Azov Sea with its shallow waters (5–12 meters) and relatively small area.

We suppose, that all the above mentioned examples are convincing enough to show the general trend of (with some rare exceptions) decrease in stock abundance and yields of nearly all marketable species at the close of the 20th century.

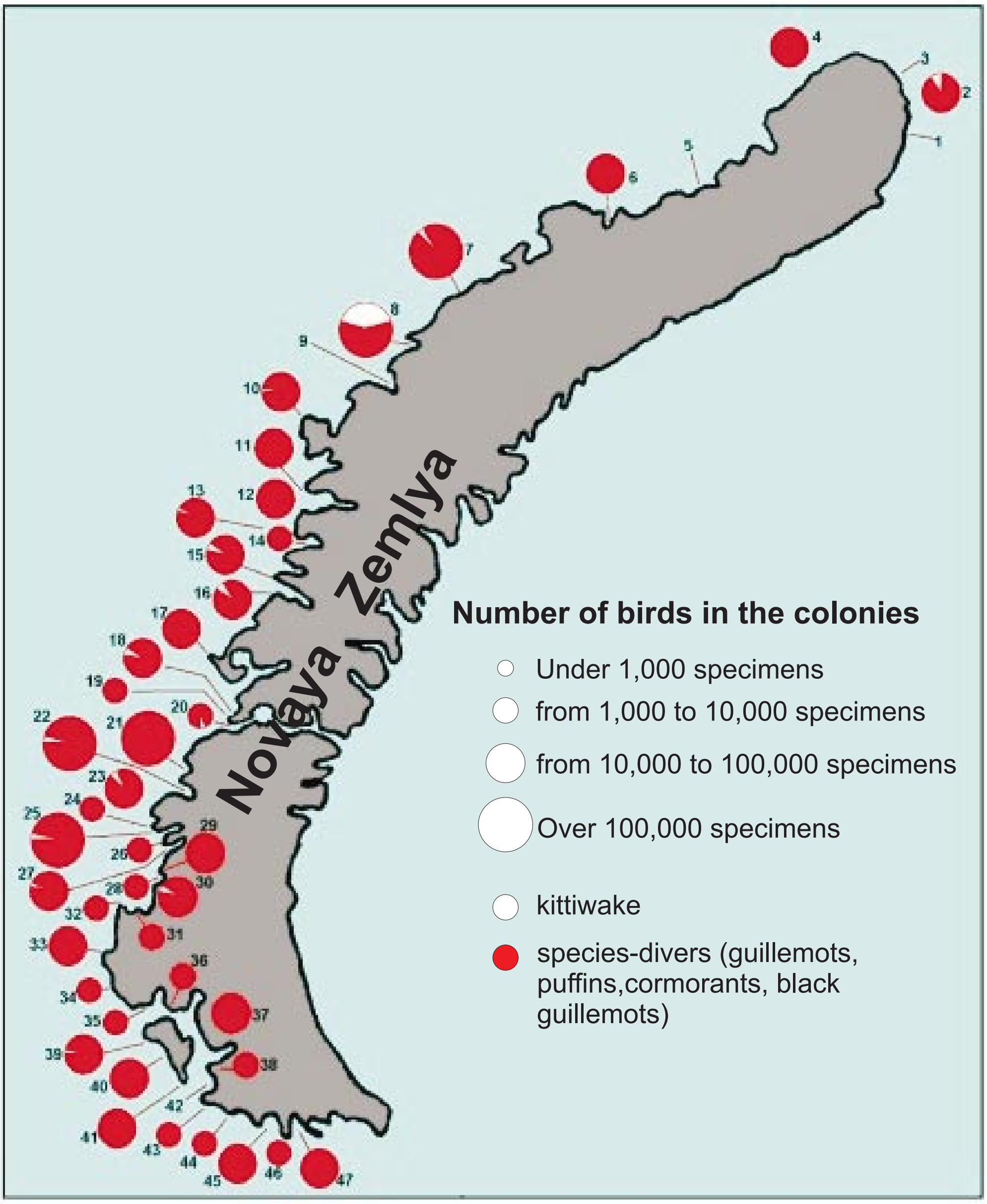


Fig. 35. Distribution and abundance of sea birds in the Novaya Zemlya colonies (by Uspensky 1956, Golovkin 1972)

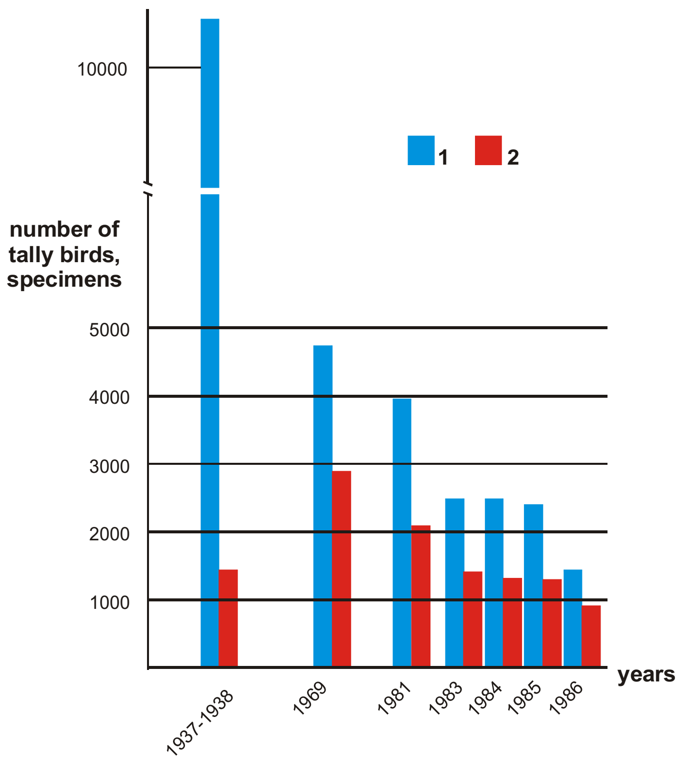
1.Cape Bismark; 2. Island Gemserk; 3. Bay of Natalia; 4. Oranskie Islands; 5. The Great Ice (Ledyanoy) Bay; 6. Russian Harbor; 7. Archangelskaya Bay; 8. Vilkitsky Bay; 9. Nordensheld Bay; 10. Sadovsky Bay; 11 Mashigin Inlet; 12. Cape Shants; 13.Cape Chernitsky; 14. Severnaya (Northern) Sulmeneva Inlet; 15. Cape Prokofiev; 16. Cape Lavrov; 17. Sykhoy Nos; 18. Mitushev island 19; Cape Serebryany (Silver); 20. Matochkin Shar; 21. Grubovaya Inlet; 22. Bezymyannaya Inlet; 23. Peninsula to the south of the Bezymyannaya Inlet; 24. Cape Britvin; 25. Pukhovy Bay; 26. Srednyaya (Middle) Inlet; 27. Kuvshin (Jug) Island; 28. Malaya Karmakulskaya Inlet; 29. Na Vilakh (Karmakusky Island); 30. Karmakulsky island ("Domashny (Domestic) bazar"); 31. Obsedia Inlet; 32. Mouth of the Talbey Yaga river; 33. Mouth of the Sauchikha river; 34. Cape Ne Bazar; 35. Cape Lilie; 36. Cape Morozov; 37. Island Yartsev; 38. Cape Valkovo; 39. Cape Shadrovsky; 40. Cape Lebediny; 41. Island Mezhdusharsky; 42. Cape Muchnoy; 43. Selesnev Inlet (northern part); 44. Selesnev Inlet (southern part); 45. In front of the Chernaya Inlet; 46. Chenrnaya Inlet (near the entrance); 47.Sakhanin Inlet

SEABIRDS AND COLONIAL BIRDS

Seabirds owing to their abundance produce the major impact on reservoir ecosystem dynamics. Effects of the impact are best seen in the coastal areas and in the areas adjacent to water fronts. Multimillion seabird populations graze on sea inhabitants (crustaceans, mollusks, fish) thus being the key element of phosphorus cycle. The Barents Sea seabirds population alone in the middle of this century amounted to tens of millions birds (**Fig.** 34, 35). The number of Brunnich's guillemots in fifty colonies at the Novaya Zemlya regardless of other species equaled 2–4 mln (Uspensky 1956).

Eggs, nest-down and meat of some species of seabirds were commercially exploited (eider, guillemot, etc). Overexploitation resulted in sharp decrease in the abundance and patrols were set up. But it was food shortage caused by overexploitation of stocks of the marketable fishes in the 1960–80s that led to drastic decrease in the density of bird colonies in the European seas. Degradation of ornitofauna was marked by mass die off of juvenile birds at the wintering sites, reproductive capacity reduction of glaucous gulls, eiders an other birds (**Fig.** 36).

The position of birds in ecological hierarchy is characterized by the specific part they take in helminthes cycle. Parasites are a stabilizer on account of their influence on the host population dynamics. Bird helminthes larvae constitute a significant (if not prevailing) segment of marine invertebrates and coastline area bound fishes parasitofauna (Krasnov et al. 1995). A sharp decrease in bird abundance disrupts parasites life cycle thus reducing coastal ecosystems resistance to outside influence.



Natural lifecycle of birds provides rich supply of carbon- and phosphorous containing substances to pelagic waters and coastal areas, which are necessary for feeding of phyto- and zooplankton, macrophytes and littoral benthos. All these contribute to high bioproductivity of seas (Krasnov et al. 1995). The weakness of ornitofauna, as a matter of fact, has negative impact on reservoir bioproductivity.

Fig. 36. Dynamics of abundance of the great black-backed (2) and herring gulls (1) on the Seven Islands in 1963-1985 (Krasnov et al.,1995)